

VARIATIONS IN THE UV SPECTRUM OF α CENTAURI

Richard P. Fahey

Laboratory for Astronomy and Solar Physics

ABSTRACT

Equivalent width and central depth measurements of the ultraviolet absorption lines from the spectrum of the He I variable star α Cen [HD 125823] are presented. The measurements are from 53 short-wavelength, and 45 long-wavelength, high-resolution spectrographs taken with the International Ultraviolet Explorer (IUE) satellite over a 25 day period during July and August of 1978. Central depth measurements were of lines of Cr III, Mn III, V III, C III, Si II, and S II seen in the region between 1245 and 1255 Å. Equivalent widths are of the three He I $2^3S - n^3P^0$ transitions found at 2945, 2829 and 2764 Å.

The period for cyclic intensity variations in He I is determined using a four-parameter, least-squares fit to a sinusoid. The IUE observations match both a period of 8.8163 ± 0.0003 days and a previously unreported period of 9.2532 ± 0.0003 days with equal minima for the least-squares fit. The phase of Cr III maximum relative to He I maximum is found to be 0.53 cycles for the IUE observations.

HE I INTENSITY VARIATIONS

Intensity changes in the spectrum of the B3 V He I variable α Cen are cyclic, with a period of roughly 8.8 days (Norris, 1971; Underhill et al., 1975). For the present study, 45 LWR and 53 SWP spectra of α Cen were obtained over a 25 day interval. From these, intensity variations in He I and in Cr III lines have been measured.

In this section two major points are discussed; (1) the measurement by equivalent width and central depth of the energy absorbed from the continuum flux of α Cen by lines of He I, and (2) the determination of the period of variation of the intensity of these lines.

THE LINES MEASURED

Among the absorption lines in the visible spectrum of α Cen, those from the He I^3P^0 states (e.g. $2^3P^0 - n^3D$) show especially strong cyclic intensity changes. In the range of IUE wavelength sensitivity, no members of these

multiplets exist. However, the members of the $2^3S - n^3P^0$ multiplets from $n = 5$ through $n = 9$ are seen. Since these are also triplet helium transitions, they were expected to vary in strength in phase with the $3P^0$ lines observed at visible wavelengths.

In July and August of 1978, 45 long wavelength spectra of a Cen were taken at uneven time intervals over a 23-day period. Well defined lines from the $2^3S - n^3P^0$ series can be seen in them at 2945, 2829, 2764, 2724 and 2696 Å. No study of the line $2^3S - 4^3P^0$ at 3188 Å is possible because the flux in the order of the IUE echellograms containing it is too weak.

QUANTITIES MEASURED

The He I lines at 2945, 2829 and 2764 Å were strong enough, and their profiles clear enough, that equivalent width measurements were appropriate to search for intensity variations in them. Measurements of the central depth of 2829 Å were also made so that the sensitivity of the two methods could be compared.

RESULTS OF MEASUREMENT

The equivalent widths of the lines 2945, 2829 and 2764 Å, as well as the central depths of the line 2829 Å, were measured. Because the width of each line varies with time, the calculation of equivalent width was always performed between the same two wavelengths for each line.

Each of the He I lines measured from the IUE spectra is from the same series in $3P^0$ transitions, thus, their average gives more information about the time variations in a Cen than any individual line does. Figure 1 gives a plot of the weighted average of all five measurements of He I lines observed by IUE versus time.

A four-parameter, least-squares fit to a sinusoid using the variable metric method of Fletcher and Powell (1963) was applied to the 45 measurements of the He I triplet series of a Cen seen with IUE.

The period determined is twofold: 8.8164 ± 0.0003 days and 9.2530 ± 0.0003 days with roughly equal fit (i.e. the sample variance and its gradient on the hypersurface are almost the same in both cases).

Because the exposure time for IUE observations was about 90 seconds for each spectrogram, it should be possible to detect cyclic changes on the order of hours or minutes. A search of the IUE He I line strength measurements for a short-time variations from 0.01 days to 1 day leads to no probable period.

REGION FROM 1245 Å to 1255 Å

Observations of the spectrum of a Cen with the Copernicus Satellite in 1975 and 1977 confirmed the fact that regions rich in Cr III, V III or Mn III absorption lines showed intensity variations consistent with the cyclic behavior of He I strength. This section presents the results of intensity measurements for 5 individual lines in 53 IUE spectrograms and a least squares fit to a four parameter sine curve for these and previously discussed lines.

IMPORTANCE OF THIS REGION

Three factors contributed to the choice of the 10 Å spectral range centered on 1250 Å for this study. First, of the two spectral regions surveyed with Copernicus in 1977, only this one is accessible to IUE. Second, the earlier study of a Cen with Copernicus in 1975 covered the entire range from 1000 Å to 1400 Å and showed no region within the range of IUE to vary more strongly than that around 1250 Å. Third, the complete multiplet Cr III (6) is identifiable.

RESULTS OF MEASUREMENTS

The absorption lines examined in the range 1245 - 1255 Å are from heavier elements than the helium discussed before. Thus, they are much less Doppler broadened due to thermal effects. Further, there are many more strong lines at these wavelengths, so many of the lines of interest are blended. In such cases, an appropriate measure of intensity is central depth.

The region from 1245 to 1255 Å was divided into three sectors for the purpose of drawing constant reference lines for each of the spectra. Examples of these lines for one sector are given in Fig. 2 which shows the spectrum at maximum and minimum absorption. These plots include the measured wavelength of each feature for which the central depth was measured.

It is worth noting that the entire region from 1245 to 1255 Å shows large, cyclic changes in flux. There are many lines from Cr III, V III and Mn III in this range that are not as strong or well-identified as those measured in this investigation. These may be contributing to the total flux change in this region as they have been observed to do in many sectors of the Copernicus spectra of the same star at these and other wavelengths.

The least squares fit to a sine curve for the Cr III lines not only gives the period of intensity changes, but also the phase relative to He I strength variations. Two give the following results

1. Cr III alone (53 data points)--The best fit to a four parameter sine curve is 9.2536 ± 0.0003 days. A second minimum in the sample variance with essentially the same value and gradient

indicates a period of 8.8160 ± 0.0003 days. The phase leads that of He I by 0.53 ± 0.01 cycles in both cases.

2. Cr III and He I from IUE (98 data points)--Here again two periods are indicated. The most probable is 9.2534 ± 0.0003 days, while the other is 8.8161 ± 0.0003 days. The Cr III data have been shifted by 0.53 cycles to allow the search for a single-period least-squares fit. The last two figures (Figs. 3,4) show the fit of a sine wave of period 9.25 days and one of 8.82 days to the combined He I and Cr III observations from IUE.

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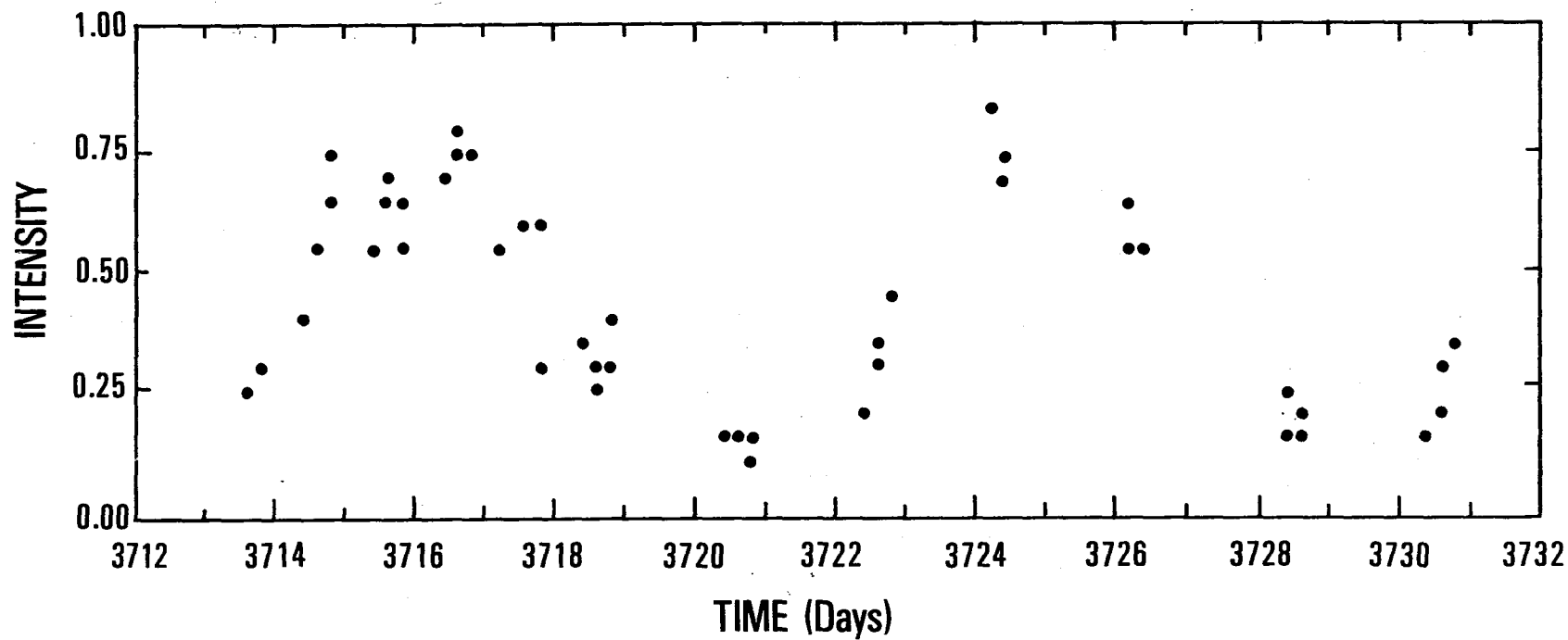


Fig. 1 - AVERAGE (After normalization) OF INTENSITY OF ALL IUE
He I LINES MEASURED vs. TIME

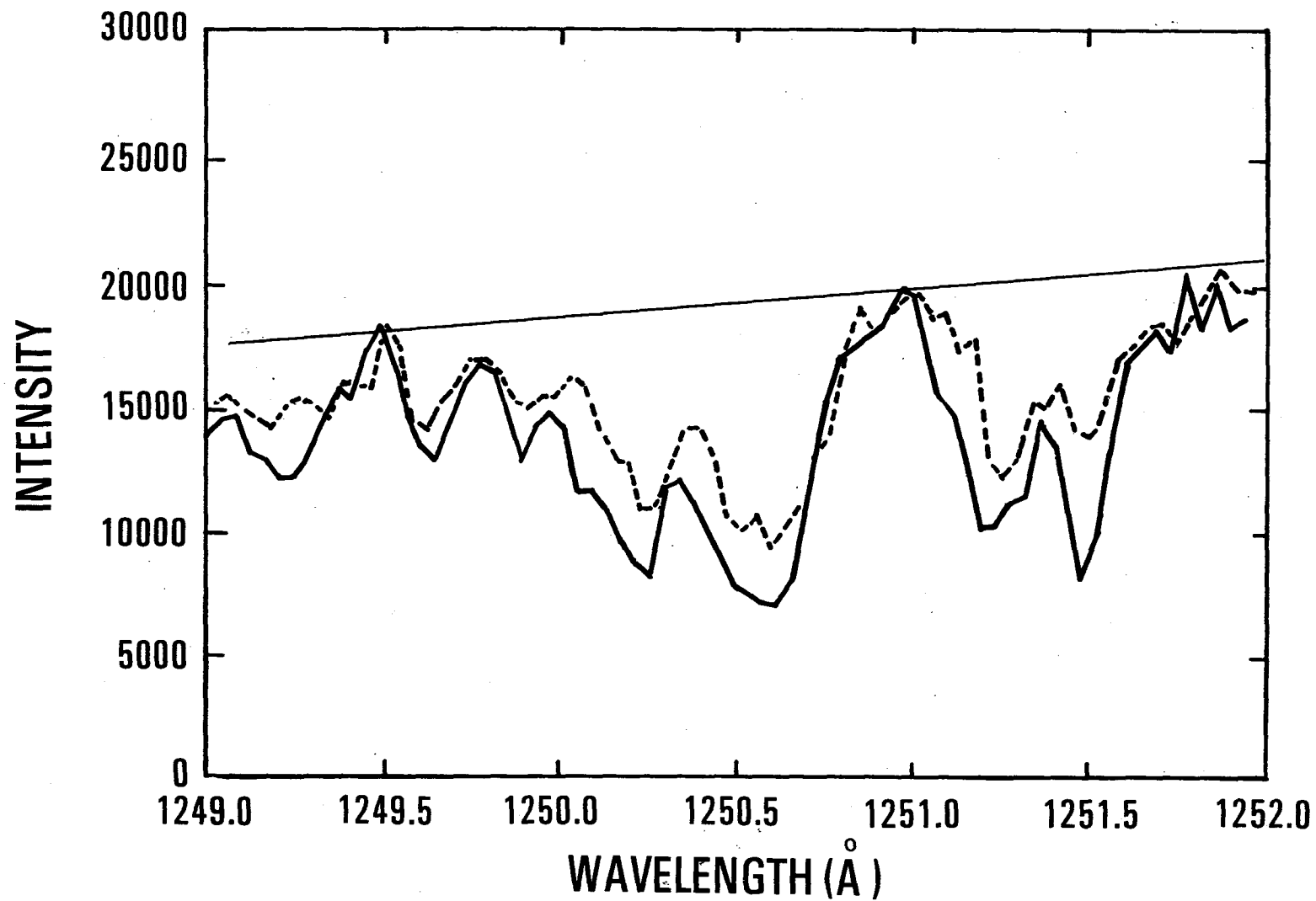


Fig. 2 - REGION BETWEEN 1249 and 1252 Å at
He I MAXIMUM (Dashed) and MINIMUM (Solid)

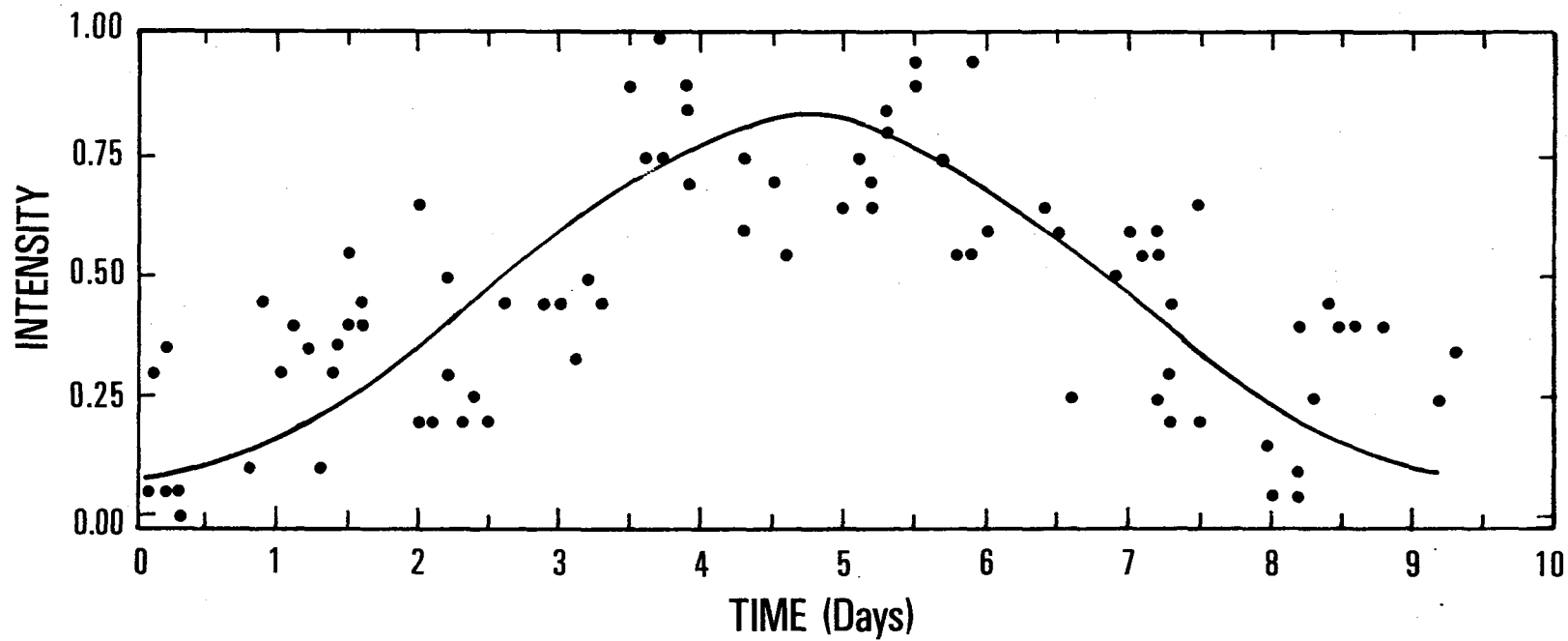


Fig. 3 - INTENSITY OF He I NAD Cr III (Shifted by 0.53 period) (Dots)
 FROM IUE OBSERVATIONS AND A SINE CURVE
 OF PERIOD 9.253 DAYS vs. TIME

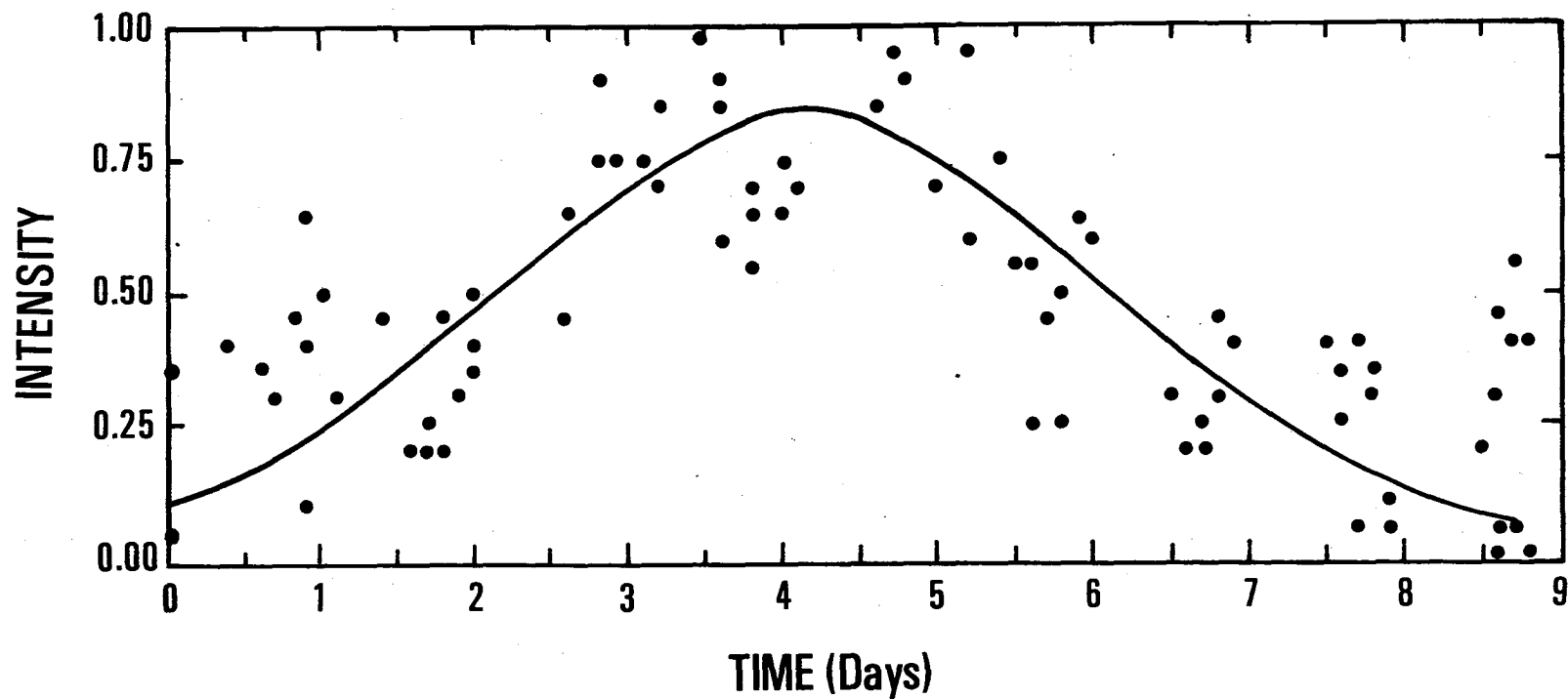


Fig. 4 - INTENSITY OF He I AND Cr III (Shifted by 0.53 period) (Dots)
AND A SINE CURVE OF PERIOD 8.8163 DAYS vs. TIME